Space Weather Technical Forecast

Issued on Friday, 24 November 2023 at 13:03 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1-R2 Radio Blackouts likely throughout. Chance of G1 Geomagnetic Storms, days 2-3 (25-26 Nov).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate activity has been observed with a peak M1.1 flare at 24/0937 UTC. This source was from AR3499 despite being a relatively magnetically simple area. There are currently twelve sunspot groups on the visible disc, the majority of which are located in the eastern solar hemisphere. In the northeast quadrant some moderately large sunspot groups appear to be magnetically connected. Of these, AR3490 continues to show the presence of a small delta spot in the southern portion of the group. Newly numbered AR3502 also shows the presence of a small delta spot. The largest group is now AR3500 in the southeast, which is a compact, bipolar group, and appears to have a delta spot.

There appears to be a possible CME associated with the M1 flare from AR3499, this looks evident on the most recent LASCO imagery but further imagery will be required in order to analyse if earth directed.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as measured by ACE and DSCOVR at L1, have been indicative of a continued waning connection to CH73/+. Wind speeds have fallen from slightly elevated levels around 470-480 km/s to background levels around 350 km/s. The solar density was generally below average. The IMF persisted at weak levels of 3-6nT. The important north-south component (Bz) has varied weakly, between +3/-4nT, though largely favoured a southward direction between 24/2128 and 25/0401. Phi angle was positive (away from the Sun). Resultant geomagnetic activity was quiet (Kp 0-2) throughout the 24 hour period.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux was generally at Moderate levels, peaking at 709pfu at 23/2000 UTC. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu), but on a steadily increasing trend. The fluence observation at 24/0000 UTC was 2.58e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate with further isolated M-class flares (R1-R2, Minor-Moderate) likely and a slight chance of isolated X-class (R3-Strong) flares, mainly from current eastern solar hemisphere sunspot regions. Despite this the recent M1.1 flare was from a relatively magnetically simple area near centre disc.

Solar Wind / Geomagnetic Activity: Two Earth-directed CMEs have been analysed and modelled, likely arriving at Earth between today and tomorrow (24-25 Nov) and day 2-3 (25-26 Nov). A further CME looks to have taken place associated with the M1 flare from AR3499 but further imagery will be required before this can be analysed.

Solar winds are now at background levels. No further coronal hole enhancements are expected until the arrival of CH75/+ later on day 3 (26 Nov), with speeds of up to 500-550 km/s possible.

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Met Office Space Weather Technical Forecast

Geomagnetic Activity will be mainly Quiet today (24th Nov), with a chance of isolated Unsettled intervals. Activity should then increase to Active to G1/Minor Storm levels with the arrival of the first CME. This is most likely to occur early tomorrow (25 Nov), but with a slight chance of occurring late today (24 Nov). Activity is expected to temporarily ease to Unsettled, then increase once again to mainly Active to G1/Minor Storm levels later tomorrow (25 Nov) into day 3 (26 Nov) given combined HSS and further expected CME influences. Day 4 (27th) Unsettled to Active (Kp 3-4) activity is expected.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels. Although there is a slightly higher risk of seeing an S1 flare in the next few hours due to the recent M1 flare, although the risk is still slight.

GOES16 Electron flux levels are expected to continue to increase in the next couple of days as the current solar wind pressure from a coronal hole continues to ease. Flux levels should increase to vary between Moderate and diurnally High levels. A suppression of electron flux to mainly background levels is expected towards the end of the period due to combined CME and HSS influences. Fluence levels are expected to remain below the 1e8 Active threshold initially, with an increasing risk of this being breached today and tomorrow (24-25 Nov) and again day 4 (27th), while temporarily decreasing into day 3 (26 Nov).

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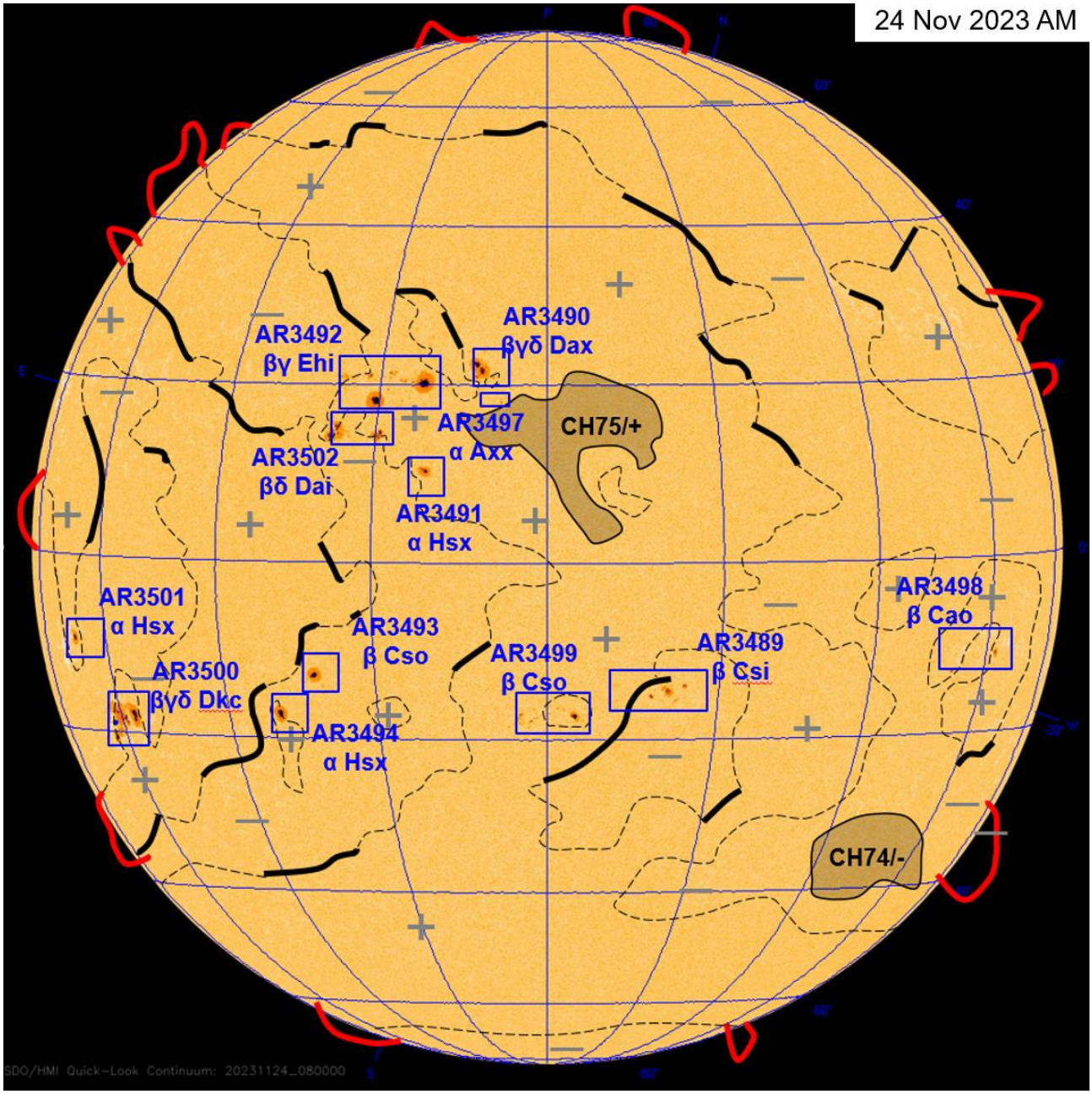
Figure 1. Solar Analysis Valid 24/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There appears to be a possible CME associated with the M1 flare from AR3499, this looks evident on the most recent LASCO imagery but further imagery will be required in order to analyse if earth directed.

Two Earth-directed CMEs feature in the forecast. The first is from a filament eruption in the southeastern quadrant early on 22 Nov. Analysis and modelling of this feature suggests that the periphery of this feature is likely to affect Earth either late today (24 Nov), or more likely early tomorrow (25 Nov). A second, partial halo CME is evident in LASCO and STEREO imagery from 22/2100 UTC onwards, directed mainly southwards. A coronal dimming spanning several hours is apparent starting around 22/1930 UTC in the vicinity of AR3489. This is also accompanied by two flare ribbons, indicative of post-eruptive magnetic re-connections in the Sun's corona following a filament eruption. Confidence is moderate for a CME arrival at Earth from this around 26/0000 UTC.

The solar winds are currently at background levels. The next HSS enhancement is anticipated from CH75/+ late on day 3 (26 Nov). On the previous rotation, this coronal hole was a much larger and darker feature than it appears currently on coronagraph imagery, with speeds reaching 570 km/s and a prolonged period of several days at elevated levels. Geomagnetic activity on the previous rotation was Kp 3-5. Therefore it is thought that similar if not a slightly muted version of events will take place upon the connection of the CH75/+ on this rotation. Speeds of up to 500-550 km/s are possible. The arrival of the HSS may coincide with the arrival of the late 22 Nov CME, so an enhancement may be initially masked by the effects of the latter.

Geomagnetic Activity will be mainly Quiet today (24th Nov), with a chance of isolated Unsettled intervals. Activity should then increase to Active to G1/Minor Storm levels with the arrival of the first CME. This is most likely to occur early tomorrow (25 Nov), but with a slight chance of occurring late today (24 Nov). Activity is expected to temporarily ease to Unsettled, then increase once again to mainly Active to G1/Minor Storm levels later tomorrow (25 Nov) into day 3 (26 Nov) given combined HSS and further expected CME influences. Day 4 (27th) Unsettled to Active (Kp 3-4) activity is expected.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	10	50	50	20
Strong	**G3**	No	1	5	5	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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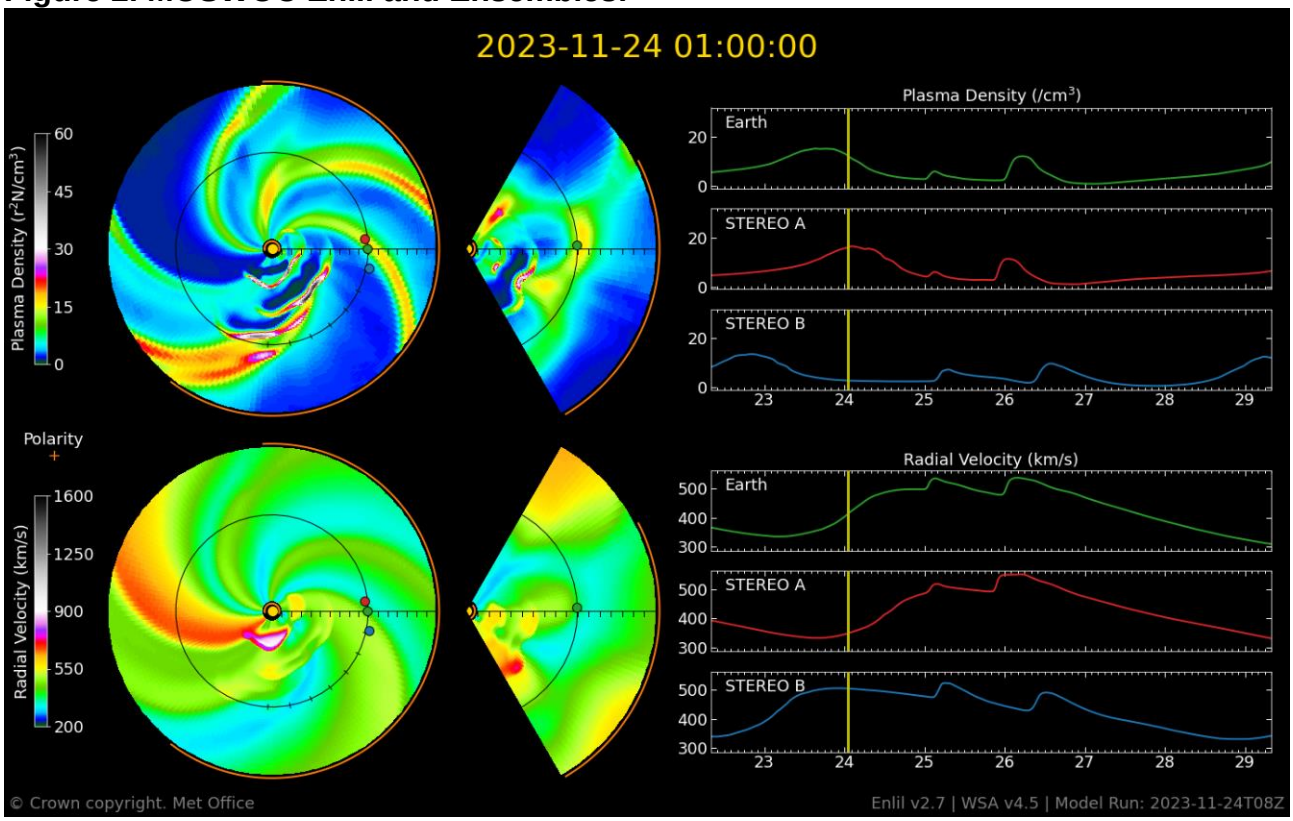
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/1241	Partial	Filament Eruption	SE	760 km/s	25/0000 UTC	Nil
23/0535	Partial	Filament Eruption	SE (near centre disc)	540 km/s	26/0000 UTC	Moderate confidence

Figure 2. MOSWOC Enlil and Ensembles:



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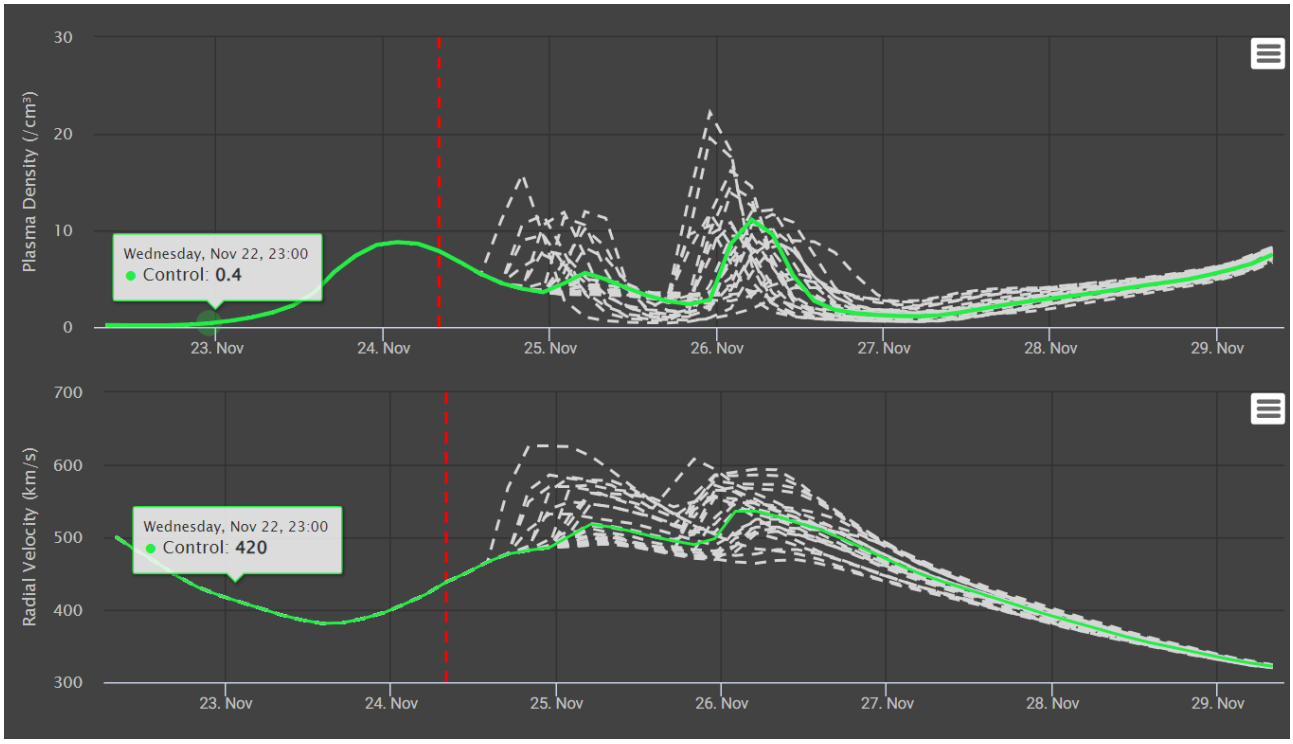

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Radio Blackouts - X-Ray Flares:

There are currently twelve sunspot groups on the visible disc. The majority of the sunspots are located in the eastern solar hemisphere. The northeast of the disc contains a cluster of sunspot groups that appear to be magnetically connected. What was previously the largest region, AR3492, has been split into two areas, with AR3502 now consisting of the spots to the south of what formally were associated with AR3492, these southern spots also contain a weak delta spot. AR3492 now consists of two moderately large leader spots and several weaker and smaller trailer spots. AR3490 continues to show the presence of a small delta spot in the southern portion of the group, and is now classified as beta-gamma-delta. The largest group is now AR3500 in in the southeast. This is a compact, bipolar group, and appears to have a delta spot.

AR3490, AR3492, AR3500 and AR3502 make up the majority of the flare risk on the disc at present, with the remaining groups smaller and more magnetically simple at this time. However, frequent CME activity close to, or just beyond the northeast limb and SDO imagery suggests the presence of further active regions that are expected to rotate onto the visible disc in the coming days.

Moderate activity has been observed with a peak M1.1 flare at 24/0937 UTC. This source was from AR3499 despite being a relatively magnetically simple area. Moderate solar activity is expected to continue with further isolated M-class flares likely, and a slight chance of an isolated X-class flare.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

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Figure 3. X-Ray flares:

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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels.

There are several moderately-large, fairly complex regions in the eastern solar hemisphere, which result in an above background risk of a S1/Minor Solar Radiation Storm. This risk remains nominal until later in the period when these groups move into a more favourable location for connection with Earth, as they approach the western solar hemisphere.

There is a slightly higher risk of seeing an S1 flare in the next few hours due to the recent M1 flare, although the risk is still slight.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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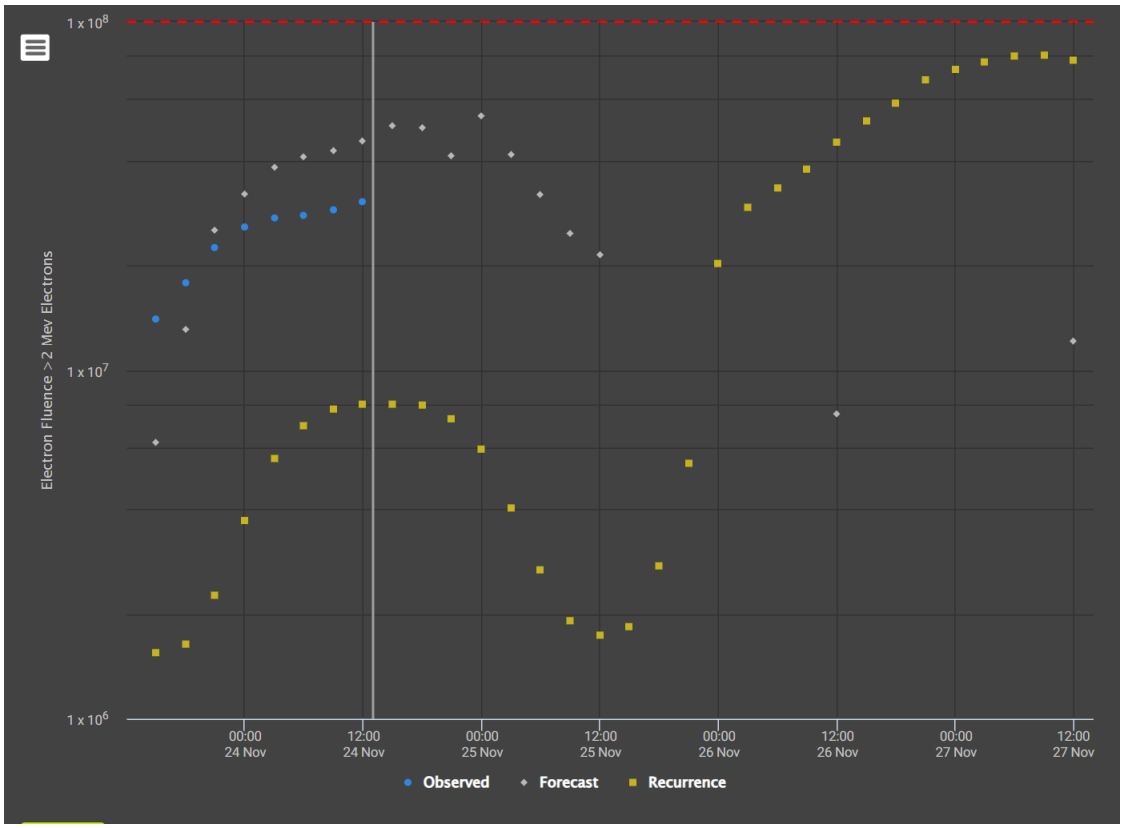
High Energy Electrons Event (≥ 2MeV):

Electron flux levels are expected to continue to increase in the next couple of days as the current solar wind pressure from a coronal hole continues to ease. Flux levels should increase to vary between moderate and diurnally high levels. A suppression of electron flux to mainly background levels is expected towards the end of the period due to combined CME and HSS influences.

Fluence levels are expected to remain below the 1e8 Active threshold initially, with an increasing risk of this being breached today and tomorrow (24-25 Nov) and again day 4 (27th), while temporarily decreasing into day 3 (26 Nov). The Met Office REFM model is initially accepted, as it indicates a rising trend in the fluence whilst the Active threshold is not breached. However, a decrease in the fluence during day 3 (26th) is preferred due to geomagnetic activity.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	40	40	10	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5. Met Office REFM:



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